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ZERO CARBON ARCHITECTURE AND RENEWABLE ENERGY TECHNOLOGIES; A PERISCOPE

Ferdinand F.O.Daminabo[1] & Ramota Ruth Obagha[2]

[1,2]Department of Architecture
[1,2]Rivers State University of Science and Technology; Nkpolu, Oroworukwo, Port Harcourt. Rivers State, Nigeria.
E-mail; ferdydaminabo@yahoo.com, ramota.obagah@ust.edu.ng

Abstract: The United Kingdom first announced its Zero carbon home policy in 2006 by the then chancellor Gordon Brown who said Britain was the first country to make such an announcement. From Hong Kong to the United Kingdom, governments across the globe pursue greenhouse gas emissions reduction targets. In retrospect, Hong Kong's electricity generation accounted for 67% GHG emissions in 2008. Buildings account for 90% of total electricity consumption in Hong Kong. It is well established that the greatest source of greenhouse gases is from buildings and building operations capsuled as embodied energy, transport and operational energy with fossils as primary source of energy. This paper focuses on pathways to zero carbon Architecture and enabling Renewable Energy Technology options for a sustainable Zero Carbon template of the future. The need to examine energy efficiency strategies and fabric energy efficiency targets will come into a sharp focus. The fact that the UK had recently backtracked on its earlier commitments, does not diminish the significance of such a laudable scheme in ensuring that emissions from buildings are minimized and that our planet is safe and not consumed by the severe effects of global warming and climate change.

Keyword*:* Zero carbon Architecture, Renewable Energy Technologies, Fabric Energy.

INTRODUCTION

Kyoto protocol was the first global attempt to curb greenhouse emissions, Figure 1 [1], viewed against the correspondence between temperature and carbon dioxide emission over time Figure 2 [2]. However historical findings had shown that Ziggurats, Sacred places, vegetative roofs and gardens had been practiced since 4000BC; a sort of green architecture if put in modern day perspectives. Presently, concerted efforts are being made to achieve the so called Net Zero Energy buildings through advances in construction technologies, renewable energy systems as well

as research efforts in the academic circuit. Net Zero Energy buildings are becoming more and more feasible in practical terms especially in the developed world.

The building sector can significantly reduce energy use by incorporating Energy-efficient strategies which are now being integrated into design, construction and operation of new buildings. Retrofits of existing buildings to improve the efficiency and reduce GHG emissions is also enjoying eclectic acceptance.

Respecting traditional building norms where building designs complied with regional and climatic models must be revisited instead of the whitewash called the international style where there are no differences between New York and Tokyo or Dubai and Nigeria with distinctive climatic variations. From the Igloos in Greenland to the Desert regions with thick thematic walls and hot humid climate with overhangs and verandas, green architecture flourished in a sustainable way even though in a small scale.

With renewable energy technologies, these traditional practices in building realization will push the Zero carbon agenda in buildings a notch further and engender a healthy and sustainable environment to live and work for a sustainable and foreseeable future and for posterity.

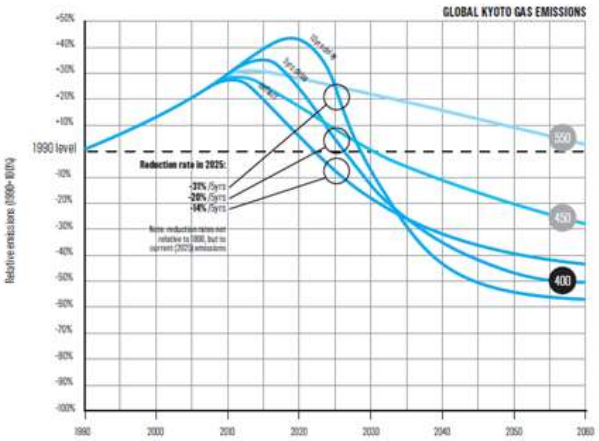


Figure 1: Emission reduction rates.Source: Meinshausen,2005

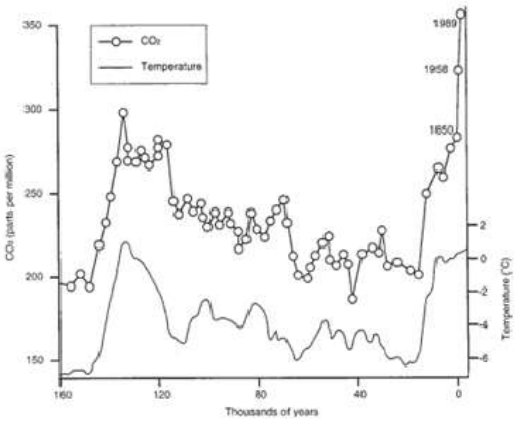


Figure 2: Correspondenc between historic temperature and carbon dioxide

AIMS AND OBJECTIVES

The pathways to emissions reductions through manipulation of design and construction processes and the use of the final product; the building is the focus of this paper. However, this is only a periscopic view in significance to actually gauge the pathways to a zero carbon Architectural realization and enabling renewable options pursuant to these goals.

Emphasis on building's energy efficiency is of paramount importance where appliances comprising a variety of products and other essentials as the building envelope and other utilities in the building come into a sharp focus.

Zero carbon Architecture cannot be sustained without the option of examining existing building regulation and standards by infusing aspects that reduces energy consumption and emissions associated with building provisions and construction.

There is consensus that a greater percentage of greenhouse gas emissions are from this sector and only by intervening in the process can there be any desired reduction in emissions to create a zero carbon environment of the future.

METHODOLGY

The identification of the fact that Zero Carbon Architecture is one of the sure routes to extricate the environment from the imbroglio of worsening global climate into a more environmentally friendly landscape is not an over statement. This research adopts an extensive literature studies and interactions with experts and stakeholders in this field. The use of a range of information gathering tools are employed and also the internet route, looking at works and resources in this field had been useful.

There is no belittling the fact that this area of study is still developing globally as individuals, organisations and experts scamper to advance the necessary technologies and sharpen the skills and knowledge necessary to achieving building efficiency that helps create a zero carbon environment with a global acceptance. The significance of this study demands wide spectrum interactions to gouge varied opinions and postulations from all sources as there are sceptics who deny that global warming is occurring. However, the scientific community are in no doubt that largely human intervention is the result of global warming and the evidence abounds from extensive scientific probing of the environment. Buildings are the largest energy consumer by sector and account for over one third of

global final energy consumption [3], thus making it a key sector of interest regarding curbing carbon emissions and slowing down the current pace of global warming.

DEFINITION OF ZERO CARBON BUILDING

A zero carbon building is a building with zero net energy consumption or zero net carbon emissions on an annual basis. Another definition of zero energy building (ZEB) is provided by Trocellini et al [4] as: "a residential or commercial building with greatly reduced energy needs through efficiency gains such that the balance of energy needs can be supplied with renewable technologies".

In many countries, zero carbon or low carbon buildings have been the focus as an important strategy at energy conservation and reduction of greenhouse gases emissions [5]. There must be convincing reasons why long-established practices should be replaced for change to be widely accepted.

Environmental degradation is foisted by the practices of perpetual use of fossil fuels, creating a hostile climate through excessive greenhouse emissions. The US Department of Energy (DOE) has set up a strategic goal to achieve 'marketable Zero-Energy Homes in 2020' [6]. However, the jettisoning of its Zero carbon home policy of 2006 just recently by the UK is as stunning as Brexit with attendant consequences even as the whole world have seen with decision of the United Kingdom to exit the European Union. In this case, its decision to vacate this policy will haunt the UK and for a long time to come even as the consequences are biting right now with dwindling pound and proportionate uncertainties and unpredictability. Sustainability emphasises the development that meets the needs of the present generation without compromising the ability of future generations to meet their own needs [7]. Sustainable development envisions a symbiotic balance between two pursuits that are often portrayed as mutually exclusive; maintenance of a sound environment, economic and social development [8, 9].

Buildings are particularly implicated in this process, being presently responsible for about 47 per cent of carbon dioxide emissions across the 25 nations of the European Union. This being the case, it is appropriate that the design and construction of buildings be a prime factor in the drive

to mitigate the effects of carbon dioxide emissions and its domino effect on the climate.

GLOBAL OUTLOOK ON ZERO CARBON BUILDING

The subject of Zero Carbon building is intractable and poses questions that appear superficially simple but surprisingly complex. Globally, buildings account for more than 40% of energy use and 24% of greenhouse gas emissions. If global efforts to respond effectively to climate change were to be well thought-out, reducing emissions from the building sector will be of critical priority.
The bewilderingly diversity of terminologies used around the world to describe green buildings can be mind bugling. However many 'green' buildings have been built in an attempt to reduce energy use and greenhouse gas emissions relative to conventional buildings.

Some of the many terms in common use include: near-zero energy; zero energy; zero net energy; passive house; energy plus; fossil fuel free; 100% renewable; zero carbon; net zero carbon; carbon neutral; climate neutral; climate positive; and positive development. While diversity is often a good thing, the many different terms and definitions used for greener buildings can be confusing and make it hard to communicate about these buildings and to judge claims made by building developers [10].

However, achieving emissions reductions will require a spotlight on energy efficiency in buildings and appliances. This will encompass a variety of products and measures such as the design and specifications with respect to the building envelope, hot water systems, lighting and large and small appliances utilised in households and offices with potential saving through improved building regulations and standards. Retrofitting of existing buildings especially as it is now occurring in developed countries with improved insulation and heating systems and adoption of renewables can deliver significant improvement [11]

BUILDING DESIGN AND ENERGY CONSIDERATIONS

The current model in buildings energy efficiency combines a rafter of design considerations such as envelope efficiency, passive and active solar features, efficiency in equipment, appliances and lighting including photovoltaic and other renewable sources to achieve zero energy targets. In buildings usually, increases of heat insulation and top performance

windows are among the most important energy-conserving methods (Hestnes et al.[12], 1997, Hensen and Nakahara, 2001)[13].

During the past 30 years, a great number of experimental buildings have been erected to measure energy conservation achieved and to serve as lessons for future design. These experiments demonstrated that buildings having very low energy consumption can certainly be designed and constructed but that this requires adequate knowledge, attention and control. (Hestnes et al., 1997)[12].

Architects, Engineers and other building construction experts must continue to engage in alternative sourcing of environmentally friendly material options with acceptable carbon footprints to forge ahead. This must also cover system and appliances efficiency and open ended research for new and compliant construction material that are sustainable with green credentials.

Lifecycle energy use in buildings can be monitored and measured as a low carbon development strategy Figure 3, as well as being seen from the perspectives of energy use, emissions and economic growth in terms of GDP per capita of countries in real-time Figure 4. The question of carbon trading is viewed as indicator of good business when assessing the alternative and renewable energy global market where countries can trade-off excess carbon footprint to other countries that emit less greenhouse gases thus stimulating economic activities on a global scale.

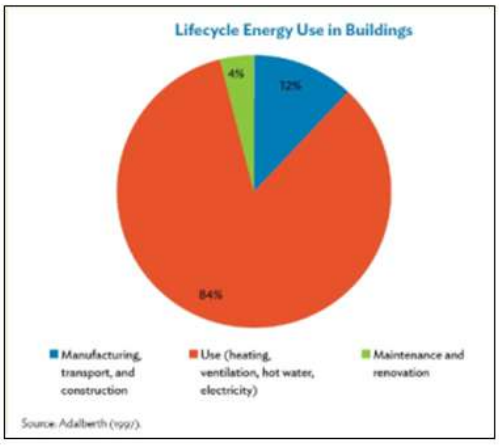


Figure 3: Societal and Lifestyle Choices as a low-carbon Strategy
Source: Adelberth, (1997)

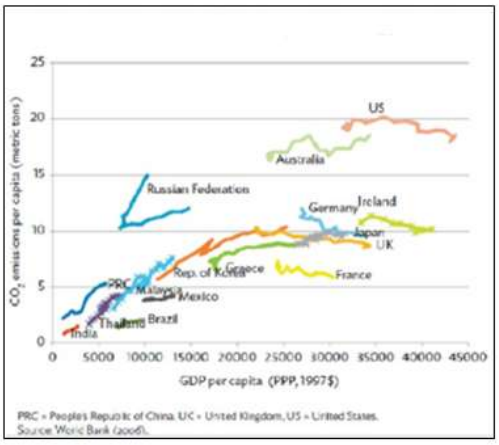


Figure 4: Energy Use, Emissions, and Economic Growth of Countries
Source: World Bank (2006)

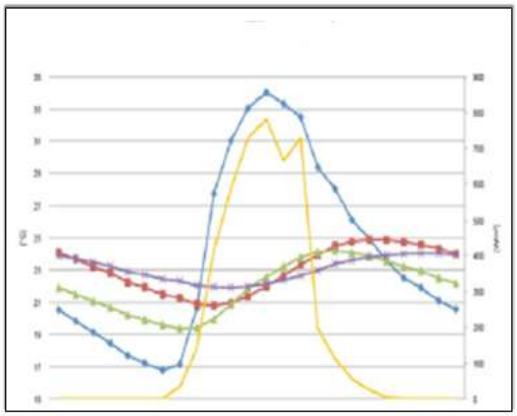


Figure 5: Tracking Surface Temperatures

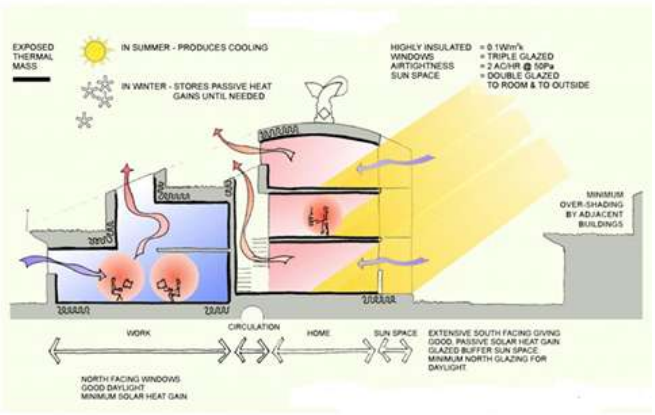


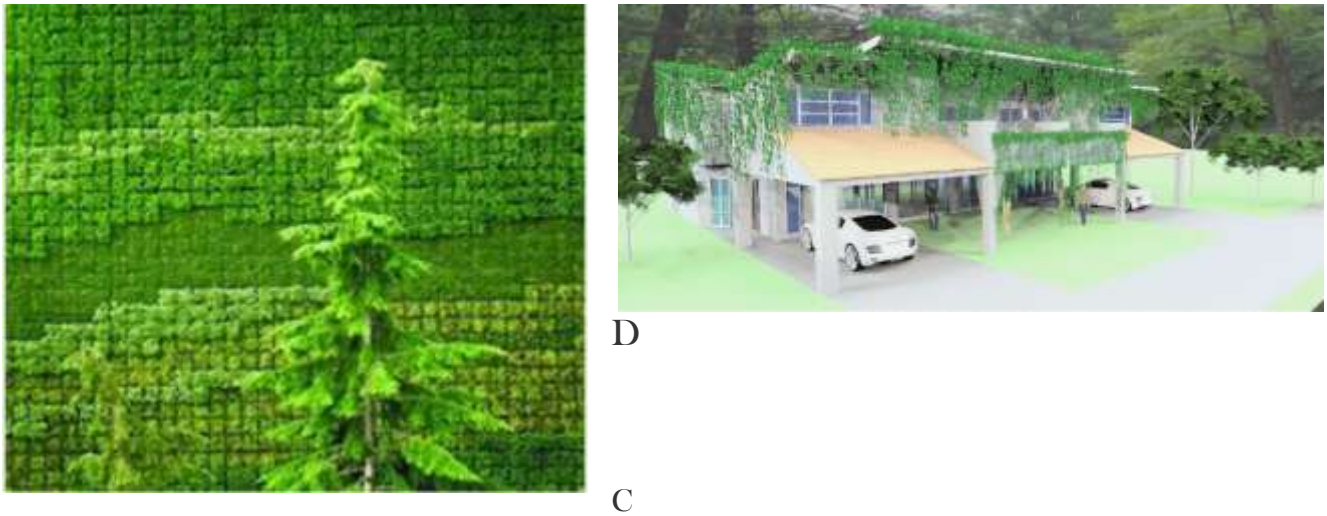
Figure 6: Building Physics

At the moment, the world is guessing what Americas' stance on the Paris Climate agreement will portend to low carbon targets and global warming. The recent decision by President Donald Trump to quite the Paris agreement has left world leaders scratching their heads and imagining what it portends to international effort to intervene in the worsening global climate, a scary climate risk indeed.

Climate not only affects individual buildings but also phenomenal influences over a larger territory, built and un-built. The study of urban climate shows certain peculiarities (such as the heat-island and canyon effect, radiation and pollution distribution, effect of green spaces), which affect architectural design (Santamouris, 2001) [14].

A

B



D

C

Figure 7: Green walls and Roofs
Source: http://www.sda-architect.com/category/article/

The effect of green walling and green roofing play key role in mitigation within the built environment especially in buildings. The advantages include carbon dioxide absorption, thermal insulation and clean air. These techniques are now being employed to achieve a realistic and sustainable green future.

Ecological architectural design synonymous with Zero carbon architecture encompasses appropriate design of architectural forms, air-tightness, optimum ventilation, selection of building materials from the category of least scarce resources ('green building materials'), energy conservation, HVAC control, good heat insulation and shading, thermal

storage, replacing ozone layer depleting heat insulation and cooling equipment. Others are protection of air, soil and water purity, recycling of wastes, increased attention to maintenance and renewal of buildings (Stratton, 2000).

According to a book authored by Spiegel and Meadows (1999) [15];
Green building materials are those that use the Earth's resources in an environmentally responsible way. Green building materials respect the limitations of non-renewable resources such as coal and metal ores. They work within the pattern of nature's cycles and the interrelationships of ecosystems. Green building materials are non-toxic. They are made from recycled materials and are themselves recyclable. They are energy efficient and water efficient. They are 'green' in the way they are manufactured, the way they are used, and the way they are reclaimed after use. Green building materials are those that earn high marks for resource management with impact on indoor environmental quality (IEQ) and performance (energy efficiency, water deficiency, etc.).

DISCUSSIONS

Protracted and often heated debates on possible routes out of Climate risks and achieving Zero Carbon Architecture especially in the domestic sector had dominated discuss on the subject, suggesting roadmaps and decarburizing the built environment and even the power sector. A large proportion of greenhouse gases had been associated with this sector.
Decisions concerning energy systems and services affect the design of buildings. Codes, regulations and standards are modified according to new knowledge and these changes have to be reckoned with in architectural design [14]. The target is usually the technological roadmap to achieving net zero carbon buildings which are energy efficient. A critical appraisal of adopted energy systems and strategy must meet the goals of efficiency in the built environment.
However, a rafter of design considerations such as choice of materials, enabling technologies, passive and active solar features, efficiency in equipment, appliances and lighting including photovoltaic and other renewable sources need to be grafted into the zero carbon equation.

The predominant energy source had been from fossils but technology is shifting in new ways focusing on renewable energy options which from the past decade is gaining traction and has not slowed in momentum despite climate change denials including the recluse of the United States from the

Paris Climate Agreement just recently by President Donald Trump who believes that global warming is a hoax and cannot be believed.

Restorative biodiversity design allows Architects restore squandered resources at ruinous neglect of organic
Architecture and so called eco-designs. This has been a teething "eco-conundrum" in the built environment.

The first zero carbon building in Hong Kong which is designed and equipped to offset operating energy consumed from the grid by on-site renewable energy generation is situated at Sheung Yuet Road, Kowloon Bay, Kowloon in Hong Kong [16]. This facility can then be said to be carbon neutral if the operating energy from the grid is neutralised by the on-site renewable generation and also negate the carbon footprint of its construction over time. Even a limited amount of offset will be of significance knowing the precarious disposition of the climate and its predictable effect on entire humanity, our corals. Our planet is at risk as we know it with extinction dangling on a knife-edge. This had been achieved with a cocktail of renewable energy systems and greening of the surrounding environment creating a micro-climate that offsets the carbon footprint; embodied energy, transport energy and construction carbon footprint.

Figure 9: The first zero carbon building in Hong Kong
Source:
www.building.com.hk/downpdf.asp

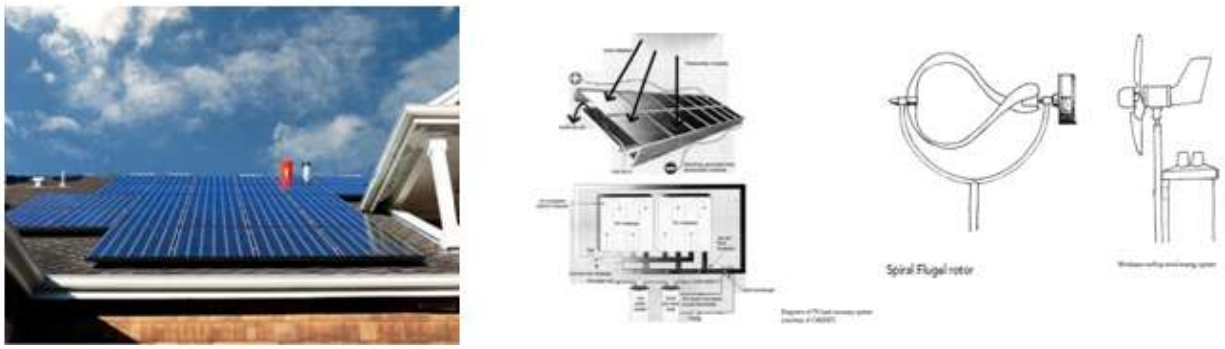
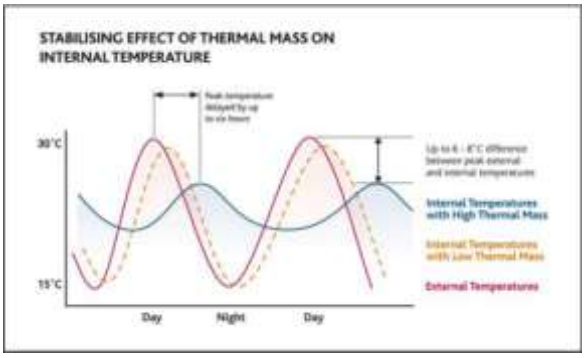


Figure 10: Cocktail of Renewable Energy Options

Source: http://www.sda-architect.com/wp-content/uploads/2016/10/PV

Figure 11 is of particular interest as a critical look at the landscape indicates what Mother Nature does best to maintain Eco-biodiversity and keep the planet habitable. The boulders at the feet of the water fall probably were bare at inception, but nature envelopes it with greenery. Zero carbon built environment will never be achieved except concerted effort are being made to our habitat and the way we live. The Hong Kong Zero Carbon building just like what nature will do is greening of parched landscapes and restoration of vegetation as will be acceptable even in the concrete jungles we call cities today. We all need the planet but the planet can do without us. The best-case scenario is nature doing it and us trying to do it, Figure 11 and Figure 12.

Figure 13: Nature's delineation of Zero-carbon template
Figure 14: Human Zero-carbon solution



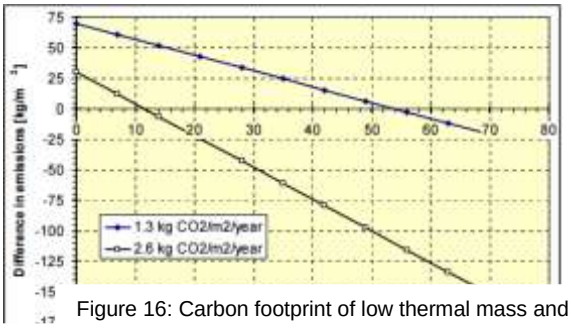


Figure 16: Carbon footprint of low thermal mass and Fluctuations; source: "Thermal Mass in housing" (ECP 2007) [17].

Fig

15: Effect of high thermal mass on daily temperature

The deployment of other energy saving mechanisms as thermal mass, systems and appliances efficiency do advance reduction in greenhouse emissions overtime apart stabilization of internal temperature in buildings with high thermal mass Figure 15[17] and Figure 16[18].

CONCLUSIONS

The fact that the UK had recently backtracked on its earlier commitments of its Zero carbon home policy in 2006; as announced by the then chancellor Gordon Brown who said Britain was the first country to make such an announcement and or climate change denials including the recluse of the United States from the Paris Climate Agreement just recently by President Donald Trump who believes that global warming is a hoax and cannot be believed, does not diminish the significance of such a laudable scheme in ensuring that emissions from everywhere including buildings are minimized and that our planet is safe and not consumed by the severe effects of global warming and climate change.

As climate risk is a the centre of a situation that will know no geographical barriers and in most cases worse in some destination the accomplishment of Zero Carbon Architecture cannot be overemphasized. This because the construction and building sector including when the finished product is in use is high-up in the emission A-list and every effort at mitigation must be channeled to achieve a sustainable carbon free future and eco friendly environment.

REFERENCES

1. Meinshausen, M. (2005): On the Risk of Overshoot – Two Degrees. Presented at "Avoiding Dangerous Climate Change", 1-3 February, M et Office, Exeter, UK

2. Peter F. Smith January, 2005: Architecture in a Climate of Change A guide to sustainable design
3. International Energy Agency, "Transition to Sustainable Buildings," International Energy Agency, Paris, 2013, p4.
Trocellini, P., Pless, S., and Deru, M. August 14-18, 2006: Zero Energy Buildings: A Critical Look at the Definition. Proc. ACEEE, Summer Study, California,.
4. http://zcb.hkcic.org/Eng/Features/whatiszcb.aspx8. accessed june,2017
5. US DOE. Multi-Year Program Plan 2011 to 2015. (http://www1.eere.energy.gov/buildings/mypp.html), accessed 18th May 2011.
6. H Christian Bugge & C Voigt, (eds), 2008: Sustainable Development in International and National Law (Europa Law Publishing, pp 88.
7. Marie-Claire Cordonier Segger and Ashfaq Khalfan, 2004: Sustainable Development Law (Oxford University Press, p1.
8. Nico Schrijver, 2008: The Evolution of Sustainable Development Law: Inception, Meaning and Status (Martinus Nijhoff Publishers), p 1.
9. https://chrisriedy.me/2012/03/13/what-is-a-zero-carbon-building/]
10. Breaking the climate deadlock technology for a low carbon future 34
11. Hestnes, Anne Grete, Hastings, Robert and Saxhof, Bjarne (Eds) (1997): Solar Energy Houses: Strategies, Technologies. Examples, International Energy Agency (IEA), James & James (Science Publishers)
12. Hensen, J.L. and Nakahara, N. (2001): Energy and Building Performance Simulation: Current State and Future Issues. Preface, Energy and Buildings, Vol. 33, No. 4, pp. vii–ix.. Santamouris, M. (Ed.) (2001): Energy and Climate in the Urban Built Environment, James & James (Science Publishers)
13. Spiegel, Ross and Meadows, Dru (1999): Green Building Materials: A Guide to Product Selection and Specification, John Wiley & Sons, Inc.
14. http://www.sda-architect.com/category/article/
15. ECP (2007), Concrete for Energy-Efficient Buildings: The benefits of thermal mass. European Concrete Platform,(http://www.europeanconcrete.eu).
16. Hacker, et al. (2006): A Life Cycle Analysis of Carbon Dioxide Emissions from Housing under Climate Change Examining the role of Thermal Mass, Prepared by Arup Research and Development for the UK Concrete Centre.
17. V. Goodright, E. Wilkes and L. Waters, 2015: "Energy Consumption in the UK," Department of Energy & Climate Change.

Reference to this paper should be made as follows: Ferdinand F.O.Daminabo & Ramota Ruth Obagha (2018), Zero Carbon Architecture and Renewable Energy Technologies; A Periscope. *J. of Sciences and Multidisciplinary Research,* Vol. 10, No. 1, Pp. 81-94